# Handsfree Decision Support: Toward a Non-invasive Human–Computer Interface*

Eric Horvitz, MD PhD

Decision Theory Group
Microsoft Research
Redmond, WA 98052
horvitz@microsoft.com

Michael Shwe, MS

Knowledge Industries
350 Cambridge Avenue
Palo Alto, CA 94306
shwe@kic.com

We have developed a prototype *handsfree* human–computer interface. The interface is composed of a computer-based Bayesian diagnostic system, speaker-independent speech-understanding, and a head-mounted, transmissive personal display that has the ability to embed translucent computer-based data, images, and inference results in a user's field of view.

The ergonomic rhythms and typical pressures of medical practice often reduce a physician's incentive and opportunities to have continuous interaction with computer-based resources. The handsfree prototype highlights opportunities for user interfaces that can provide *real-time* and interactive decision support with minimal changes to existing patterns of clinical activity. Handsfree user interfaces show promise especially for use in *procedure-oriented* specialties such as emergency medicine, anesthesiology, and surgery. In procedure-oriented specialties, automated reasoning and decision support should not interfere with a physician's hands, and cannot obscure the physician's view of the patient.

A schematic overview of the handsfree decision-support system is displayed in Figure 1. The speech-understanding system allows a user, through voice commands, to navigate through menus and to enter information about signs, symptoms, and test results analyzed by the expert system. The transmissive display overlays the expert system's output on the clinician's view of the world. The display continues to provide the user with a variety of input and inference options. In our tests, we provided users with recommendations on the value of additional information and the computed differential diagnosis with associated probabilities of diseases.

We incorporated results from the earlier studies of speech recognition into a modification of the graphical user interface for the handsfree system. We validated the performance of the handsfree system with a Bayesian-network knowledge base for diagnosing severe abdominal pain in patients in several contexts, including emergency department and inpatient settings. The speech understanding component performed well. On a two-hundred word vocabulary, trained with 6 speakers, we found that the overall recognition was greater than 96% before addition of the menu-driven focusing provided by the diagnostic system. We further increased accuracy of the system by exploiting valuable synergies between the speech understanding system and the menu-driven Bayesian expert system; during the speech interaction, a higher recognition priority was placed on terms that would likely be uttered by the user, as determined by the context. We found that we could adapt the discrete speech paradigm to follow natural patterns of pauses between phrases that users employ to enter data to the expert system by setting timer thresholds. As part of the project, we designed a software module that automatically generates a speech vocabulary file from the words embedded in user-interface menus and in the knowledge base. More detailed descriptions of the handsfree human-computer interface are available from the authors.

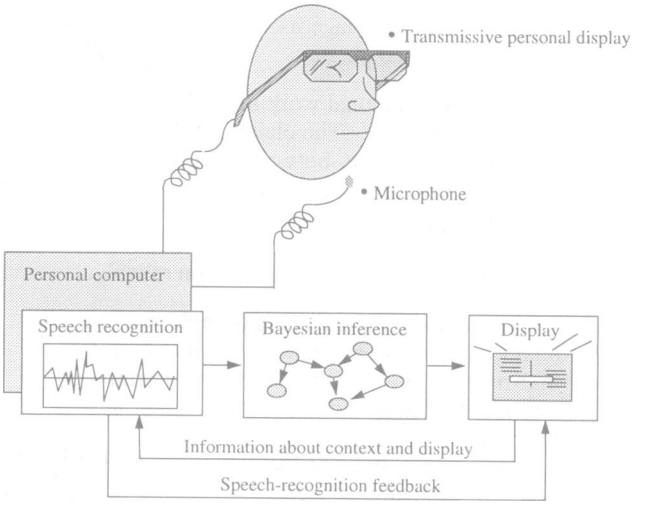


**Figure 1.** Key components of handsfree decision-support system. A transmissive personal display relays speech recognition feedback as well as core information on the differential diagnosis and the best information to gather next.

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